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Section 2

Bi 1 HW 2

1a) Assume that:

- The average adult male killer whale weighs about 4700 kg, and the average female about 2800 kg
- The metabolic rate of animals scales roughly with $\frac{3}{4}$ the power of their mass
- The rate for a roughly 100 kg human is about 2000 $\frac{\text{kcal}}{\text{day}}$
- One day contains $24 * 60 * 60 \approx 80{,}000$ seconds
- 1 kcal is equivalent to ~ 4000 J

We know that the male whale is about 50 times heavier than the average human, and the female whale about 30 times heavier. This gives us (for the male) $rate \approx 50^{3/4} \approx 10$ times that of a human, so the rate is about $\mathbf{20{,}000\ \frac{kcal}{day}}$. For the female, we have $rate \approx (30)^{\frac{3}{4}} \approx 10$ so the rate is also about $\mathbf{20,000\ \frac{kcal}{day}}$. These are equivalent to $20{,}000\ \frac{\text{kcal}}{\text{day}} * \frac{1\text{day}}{80{,}000\text{ s}} * \frac{4000\text{J}}{1\text{ kcal}} = \mathbf{1,000\ w}$ (for both the male and female).

1b) Assume that

- The adult male/female consumes about 200,000 $\frac{\text{kcal}}{\text{day}}$ (from figure 3 below).
- The average adult sea otter has a mass of about 30 kg, and each otter yields about 7 $\frac{\text{kJ}}{\text{g}}$ of energy

- Thus, each otter gives $30\text{kg} * 7000\,\frac{\text{kJ}}{\text{kg}} \approx 200{,}000$ kJ energy contribution
  - 1 kcal is equivalent to $\sim$4000 J (4 kJ)

We thus know that each otter gives $200{,}000\text{kJ} * \frac{1\text{kcal}}{4\text{kJ}} = 50{,}000$ kcal. Therefore, the male (and female) whale must eat $\frac{200{,}000}{50{,}000} =$ **4 otters**.

1c) Assume that

- 100% of the otters remain in the year 1990 (60,000)
- 20% of the otters remain in the year 2000 (about 10,000)
- The rate of otter loss is roughly constant from 1990 to 2000
- The average orca must eat about 4 otters per day (from part b, this is the average over both male and female orcas)

Thus, we know that the average rate of otter loss is $\frac{500{,}000\text{ otters}}{10\text{ years}} = 50{,}000\,\frac{\text{otters}}{\text{year}} * \frac{1\text{ year}}{365\text{ days}} \approx 100\,\frac{\text{otters}}{\text{day}}$. The number of whales responsible for this is thus roughly $\frac{100\frac{\text{otters}}{\text{day}}}{4\frac{\text{otters}}{\text{day}*\text{whale}}} \approx$ **30 whales**.

1d) Assume that

- The coastline extends 200 nm outwards and is 2000 km long.
- The typical orca density in this area is about $4\,\frac{\text{orca}}{1000\text{ km}^2}$
- About 10% of killer whales are transent (feed on marine mammals)

Our region has side length of 200 $nautical\ miles * \frac{1.8\ km}{1\ nm} \approx 400\ km$, and our area is thus $400 * 2000\ \text{km}^2 \approx 800{,}000\ \text{km}^2$. If we have a density of $4\,\frac{\text{orca}}{1000\ \text{km}^2}$, then we have $800{,}000\ \text{km}^2 * 4\,\frac{\text{orca}}{1000\ \text{km}^2} \approx \mathbf{3,000\ orca.}$ If about 10% of orca are transient, then we have about $(.10) * (3000\ \text{orca}) = \mathbf{300\ orca}$ that are transient.

1e) Assume that:

- The summer in Alaska has daylight 24 hours a day (roughly), and there is at least one person observing constantly
- The observers work for 10 weeks during the summer, and do this for 6 summers
- At all times, there are about 10 expeditions going at once
- There are an average of about 10 people on deck observing at once

This gives us a total time of

$$6\ \text{summers} * 10\,\frac{\text{weeks}}{\text{summer}} = 60\ \text{weeks} * 7\,\frac{\text{days}}{\text{week}} \approx 400\ \text{days} * 24\ \frac{\text{hours}}{\text{day}} \approx$$

$$10000\,\frac{\text{hours}}{person*ship} * 10\ people * 10\ ships = \mathbf{10^6\ human\ hours}$$ spent observing.

1f) Assume that

- $50{,}000\,\frac{\text{otters}}{\text{year}}$ were killed over this 6 year period for a total of 300,000 attacks
- About 1 km^2 at a time can be seen per boat, and there are 10 boats
- The total length of the coastline is about 2,000 km (from 1d)
- The coastline extends about 1 km in either direction outwards, so 2 km total
    - This gives us a total area of 4,000 km^2

- The coastline is being viewed for 10 weeks of the year

Thus, the fraction of coastline actually visible at a time is about $\frac{10 \text{ km}^2}{4{,}000 \text{ km}^2} \approx 3 * 10^{-3}$ when it is being viewed. If it is being viewed for 10 weeks of an (approximately) 50 week year, then we have $(3 * 10^{-3}) * \left(\frac{10}{50}\right) \approx 6 * 10^{-4}$ as the fraction of all attacks viewed. Thus, the total number of attacks viewed is about $(6 * 10^{-4}) * (300{,}000) \approx$ **200 attacks.**